CHAPTER 8
Potential Economic Impacts of U.S. Offshore Aquaculture

Gunnar Knapp

In this chapter, we discuss two types of potential economic impacts of U.S. offshore aquaculture:

- *<u>Employment and Income Impacts</u>: Potential employment and income which might be created, directly and indirectly, from U.S. offshore aquaculture.*

- *<u>Market-Driven Impacts</u>: Potential impacts of U.S. offshore aquaculture on prices and production volumes of U.S. wild and farmed fish, and market-driven changes in net economic benefits to U.S. fishermen, fish farmers and consumers.*

Our focus is on describing the general nature of these types of economic impacts, and the factors that may affect their potential magnitude.[1]

Challenges in Assessing Economic Impacts of U.S. Offshore Aquaculture

There are several major challenges in assessing potential economic impacts of United States offshore aquaculture, which are similar to the challenges in assessing economic potential for U.S. offshore aquaculture which we noted in Chapter 2.

First, potential United States offshore aquaculture is very diverse. The United States has a very large exclusive economic zone with waters ranging from arctic to tropical. There are many different species which could be farmed in the U.S. EEZ, using many different types of technologies. The economic impacts of offshore aquaculture may vary widely for different regions, species, and technologies.

Second, the economic impacts of United States offshore aquaculture will depend on how it is regulated. Regulations for offshore aquaculture will directly affect what technologies may be used, where aquaculture might develop, what species might be farmed, the scale of potential projects, how long it takes for projects to be permitted and developed, costs of taxation, costs of environmental monitoring, the extent of local hire and control, and so forth. Thus part of the answer to the question to "what kind of economic impacts will offshore aquaculture have?" depends on the answer to the question "what kind of economic impacts do we want offshore aquaculture to have?"

A third challenge is that the U.S. offshore aquaculture industry is still in its infancy. Although we can speculate about what future U.S. offshore aquaculture may look like, we do not yet know what technologies may evolve, which species and regions will have the most economic

[1] Note that this chapter does not address economic impacts associated with potential environmental "externalities" of offshore aquaculture, which are addressed in other chapters of this report. Note also that the discussion of economic impacts in this chapter should be distinguished from cost-benefit analysis, or formal comparison of costs and benefits of offshore aquaculture.

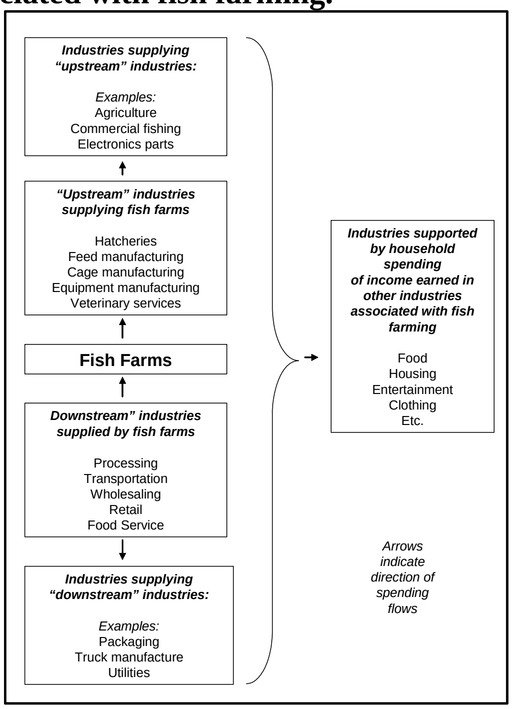
potential, what inputs the evolving U.S. offshore aquaculture industry may purchase, what the markets for its products will be, or what prices those products may command.

Perhaps most importantly we do not know what the *scale* of future U.S. offshore aquaculture may be, or how fast it will grow to achieve that scale. Most (although not all) economic impacts of offshore aquaculture would be roughly proportional to the scale of production. Depending on the scale of production, the economic impacts of offshore aquaculture could be very small—or very large.

Employment and Income Impacts of Offshore Aquaculture

Figure 8.1 provides a simple categorization of industries associated with fish farming—those industries which depend in some way on fish farming. We may group these industries into six categories:

Figure 8.1. Industries associated with fish farming.



- <u>Fish farms</u>. These are aquaculture operations growing fish or shellfish.

- <u>"Upstream industries" supplying fish farms.</u> These are industries from which the fish farms purchase direct inputs. Among the industries which account for the greatest share of fish farm purchases are hatcheries, feed manufacturing, and cage and equipment manufacturing.
- <u>"Downstream" industries supplied by fish farms.</u> These are industries in the distribution chain from fish farms to consumers, including processing, transportation, wholesaling, retail and food service.

- Industries supplying upstream industries. These are industries from which the "upstream" industries purchase inputs. For example, the feed manufacturing industry purchases raw material for making fish feed from both the agriculture and the commercial fishing industries.

- Industries supplying downstream industries. These are industries from which the "downstream industries purchase inputs. For example, the processing industry purchases boxes from the packaging industry.

- Industries supported by household spending. These are industries throughout the entire economy that are supported by spending of household income earned in the other industries.

Clearly the nature and degree of association with fish farming varies widely among these different categories of industries. There are only a few industries which would disappear entirely without fish farming, such as cage manufacture. However, there are many industries, across many sectors of the economy—which benefit in some way from fish farming.

Figure 8.1 helps to illustrate two simple but important points. First, the economic impacts of fish farming are larger—potentially much larger—than those which occur at fish farms. We cannot count the employment created by aquaculture simply by adding up the jobs at aquaculture companies.

Second, the economic impacts of fish farming are spread over a far greater geographic area than the communities where fish farms are located or from which they are supported. While the hatchery supplying a fish farm may be located relatively near the farm, the company manufacturing the cage or the restaurant selling the fish may be located thousands of miles away.

One indicator of the relative significance of "upstream industries" in aquaculture production is the share of purchased product inputs in gross output value. As shown in Table 8.2, purchased inputs accounted for 69% of total gross output value of Canadian aquaculture in 2005, and feed purchases alone accounted for 31%. The shares of different inputs varied between provinces, reflecting different mixes of species in total production.

Viewed in a different way, gross value added in Canadian aquaculture was only 31% of gross output in 2005. Thus more than two-thirds of gross output value was generated in other "upstream" industries.

Table 8.1. Estimated share of selected expenditures in gross output value of Canadian aquaculture, by province, in 2005.

	Newfound-land	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	British Columbia	CANADA TOTAL
Purchased product inputs	**59%**	**24%**	**47%**	**75%**	**40%**	**43%**	**74%**	**69%**
Feed	28%		24%	29%		24%	38%	31%
Eggs and fish for growout	7%	8%	7%	10%	2%	5%	3%	6%
Processing services	4%	2%	0%	4%	0%		10%	6%
Goods transportation & storage	4%	1%	2%	2%	1%	1%	7%	4%
Energy	2%	2%	2%	1%	8%	3%	2%	2%
Maintenance & repairs	2%	3%	1%		3%	1%	3%	3%
Insurance premiums		0%	1%	2%	1%	0%	2%	2%
Rental & leasing expenseses	1%	2%	0%	1%	1%	1%	1%	1%
Professional services	2%	1%	1%	1%	2%	1%	1%	1%
Therapeutants			2%	1%			2%	2%
Gross value added (factor cost)	**33%**	**76%**	**53%**	**25%**	**59%**	**57%**	**27%**	**31%**
Salaries & wages	11%	37%	17%	12%	19%	17%	11%	13%
Finfish share of production volume	61%	0%	64%	94%	25%	100%	87%	75%

Source: Calculated from value-added account data in Statistics Canada, *Aquaculture Statistics 2005* , Catalogue no. 23-222-XIE. Estimates were based on taxation data and a sample of 148 establishments. Blank cells indicate estimates were not available.

Estimating Total Employment and Income Impacts of Fish Farming

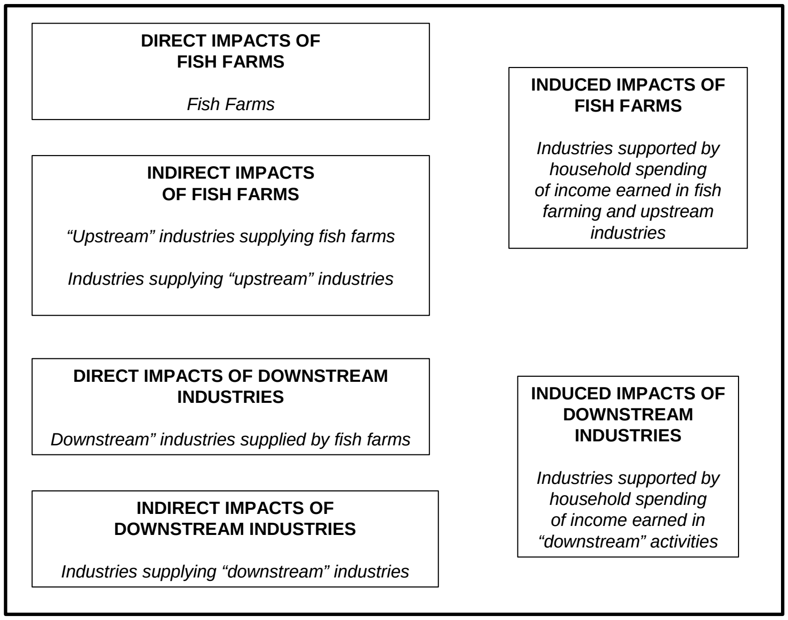
Adding up how many people work on fish farms and what they earn is a relatively straightforward process. Speculating about how many people might work on future offshore fish farms is also relatively straightforward (although highly uncertain given uncertainty about the future scale and characteristics of the industry). It is far less straightforward to measure the full economic impacts, across all industries, of existing fish farms--or to project the potential full economic impacts of future fish farms.

The standard technique for estimating economic impacts of an industry is input-output analysis, which calculates economic impacts using assumptions about inter-industry purchases per dollar of output of an industry. These are then used to caculate three types of economic impacts: “direct,” “indirect,” and “induced.” Applied to fish farming, “direct impacts” are those occurring within the fish farming industry; “indirect” impacts are those driven by purchases of the fish farming industry from other industries, and “induced impacts” are those driven by household spending of income created by direct and indirect impacts. . Each of these types of impacts is typically measured in three ways: annual average employment, wage and salary income, and sales or “output.”

Input-Output analysis typically measures only the impacts of an industry and its associated upstream activities. If we wish to measure the impacts of the “downstream” activities of processing and distributing farmed fish, we may apply the same approach to estimating the direct, indirect and induced impacts of these industries (net of those associated with fish production).

A significant challenge for input-output analysis is that it requires extensive data on inter-industry purchases. This is particularly a challenge for marine aquaculture, partly because it relies heavily on purchases from other industries, and partly because it is a relatively new industry for which relatively little data are available.

Figure 8.2. Types of economic impacts of fish farming estimated by economic impact modeling.



The National Offshore Aquaculture Model is an input-output model which was developed for the specific purpose of estimating potential economic impacts of offshore aquaculture. Chapter 7 of this report uses this model to estimate economic impacts for hypothetical offshore farming operations for five different species. For each species, the model required specific assumptions about the scale of the operation and different kinds of expenditures such as farm installation costs, vessel maintenance, feed costs, etc. The model then calculates direct, indirect and induced impacts generated by the farming operation as well as “downstream” activities.

Details of the model’s economic impact calculations are presented in Chapter 7. The purpose of our brief discussion here is to contrast the relative scales of different kinds of projected impacts, and of impacts from different kinds of farming.

As shown in the first row of Table 8.2, the direct employment impacts of fish farming account for between only 11% and 19% of the projected total employment impacts of farming from all upstream and downstream activities as well as induced activity in the rest of the economy. As shown in the fourth row, the total impacts attributable to farming (as opposed to downstream activities) represent only 27% to 38% of total impacts.

These estimates serve to emphasize the point made above: the potential total economic impacts of offshore fish farming are much larger than those which would occur at the farming operations alone—potentially five to ten times larger. Put differently, simply adding up jobs and wages at the farms would greatly underestimate the total economic impacts created by offshore farming.

Table 8.2. Share of estimated employment impacts of potential offshore aquaculture operations.

	Blue mussel	Sea scallop	Cod	Atlantic salmon	Winter flounder
Farming direct	11%	11%	15%	14%	19%
Farming indirect	4%	1%	10%	6%	7%
Farming induced	13%	16%	12%	16%	12%
Farming total	**27%**	**29%**	**36%**	**35%**	**38%**
Downstream direct	43%	43%	38%	38%	37%
Downstream indirect	3%	2%	2%	2%	2%
Downstream induced	26%	26%	24%	24%	23%
Downstream total	**73%**	**71%**	**64%**	**65%**	**62%**
Combined direct	53%	54%	52%	52%	56%
Combined indirect	7%	4%	12%	8%	9%
Combined induced	39%	42%	35%	40%	35%
Combined total	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Full-time and part-time employment impacts estimated for different types of offshore aquaculture operations using the National Offshore Aquaculture Model, presented in Chapter 7.

Note however that the total economic impacts depend on the extent to which offshore aquaculture would increase total U.S. fish consumption, as opposed to offsetting fish imports. If production from U.S. offshore aquaculture replaces an equivalent amount of imports, then some of the model's projected downstream impacts--particularly those deriving from retail and food service--should be excluded, because these activities would occur regardless of whether future U.S. consumption is from U.S. farms or imported fish.

Table 8.3 shows the model's projections of employment impacts per thousand metric tons of annual production for each species.[2] The important point we wish to emphasize here is not the specific impacts projected for any particular species, but rather the fact that <u>there is wide variation between species in the scale of potential economic impacts associated with a given production volume</u>. This is to be expected, given the fact that technologies of fish farming vary widely depending upon what species is being farmed and how it is being farmed.

Estimates of Fish Faming Employment

Table 8.4 shows estimates of annual average employment in aquaculture per thousand metric tons of production, for various regions and species, from a number of different sources. The estimates are for inshore marine aquaculture and onshore aquaculture, which likely differ in their employment impacts from those of potential future U.S. offshore farms. The definitions of "employment" and the methodologies used to derive the estimates of employment vary considerably between sources.

The employment estimates are only for direct employment in fish farming. As discussed above, total employment created by aquaculture in these regions, after accounting for indirect

[2] Note that these projections depend upon the specific assumptions used in the model about the scale and technology of each farming operation.

and induced upstream impacts of upstream and downstream activities, is likely much larger—potentially five to ten times as great.

Table 8.3. Estimated employment per thousand metric tons of annual production in potential offshore aquaculture operations.

	Blue mussel	Sea scallop	Cod	Atlantic salmon	Winter flounder
Farming direct	11	155	70	36	146
Farming indirect	4	18	47	15	53
Farming induced	13	218	56	43	91
Farming total	**29**	**391**	**173**	**93**	**290**
Downstream direct	45	588	180	101	284
Downstream indirect	3	32	12	6	18
Downstream induced	28	360	113	63	178
Downstream total	**76**	**980**	**305**	**170**	**480**
Combined direct	56	743	250	136	430
Combined indirect	7	50	58	21	71
Combined induced	41	578	169	106	268
Combined total	**104**	**1370**	**477**	**263**	**770**

Source: Full-time and part-time employment impacts estimated for different types of offshore aquaculture operations using the National Offshore Aquaculture Model, presented in Chapter 7.

The employment impacts associated with a given volume of aquaculture production vary widely depending upon the species, region, and technology and scale of production. In general, labor productivity is much higher in large-scale salmon farming, resulting in the creation of fewer direct farming jobs per thousand metric tons of production than smaller-scale farming of other species.

Norwegian salmon and trout farming—probably the most labor-efficient large-scale aquaculture in the world—creates about 5 direct farming jobs per thousand metric tons of production. In contrast, aquaculture in general, reflecting smaller-scale production of a mix of finfish and shellfish species, tends to create between 20 and 50 direct farming jobs per thousand metric tons of production.

Detailed cost and employment data compiled annually for the Norwegian aquaculture industry help to illustrate the basic point that the number of jobs created by fish farming depend upon scale, technology and economics. Between 1992 and 2003, Norwegian salmon and trout production more than quadrupled while total employment in Norwegian salmon and trout farming declined (Figure 8.3). As a result, employment per thousand metric tons of salmon and trout production fell from 24.4 to 5.7 (Figure 8.4)—reflecting a dramatic increase in labor productivity as the scale of the industry increased.

Table 8.4. Selected estimates of aquaculture employment, various species and regions.

Species	Region	Year	Source & Notes	Live weight (metric tons)	Estimated employment	Estimated employment per thousand metric tons
All aquaculture	Newfoundland	2005	1	8,163	200	25
	Prince Edward Island			18,921	620	33
	Nova Scotia			8,917	250	28
	New Brunswick			37,657	1,250	33
	Quebec			1,215	155	128
	Ontario			4,000	150	38
	British Columbia			73,195	1,275	17
	CANADA TOTAL			152,068	3,900	26
All aquaculture	Austria	1997	2	4,274	379	89
	Belgium			1,471	112	76
	Denmark			38,250	698	18
	Finland			16,365	809	49
	France			211,205	10,342	49
	Germany			59,069	3,193	54
	Greece			54,947	2,711	49
	Ireland			35,101	1,275	36
	Italy			211,919	4,923	23
	Netherlands			97,640	564	6
	Portugal			8,781	1,452	165
	Spain			233,693	7,851	34
	Sweden			6,523	480	74
	United Kingdom			128,525	2,705	21
	EU TOTAL			1,107,763	54,029	49
All aquaculture	Europe	1998	3	1,315,000	57,000	43
Salmon	N. Brunswick	2000	4	29,100	1,683	58
Salmon	Maine	2002	5	6,695	240	36
Salmon	Scotland	1997	6	99,197	1,647	17
Salmon	Scotland	2002	7	143,000	1,552	11
Salmon & trout	Norway	2000	8	488,839	3,631	7
		2005		645,387	3,054	5
Species other than salmon & trout	Norway	2000	8	1,439	400	278
		2005		11,507	606	53
Catfish	Mississippi	2001	7	172,789	3,000	17

See following page for sources & notes.

Table 8.4. (continued).

Selected Estimates of Aquaculture Employment, Various Species and Regions: Sources & Notes

General notes: To the extent possible, employment data are estimates of full-time-equivalent employment in fish farming (excluding upstream or downstream impacts, including processing). The kind of employment data collected and/or estimated varies between studies. See notes for individual sources for additional details.

(1) Fisheries and Oceans Canada. 2006. Canadian Aquaculture Industry, 2004-2005: Key Figures. www.dfo-mpo.gc.ca/Aquaculture/ref/kf0405_e.htm.

(2) MacAlister Elliott and Partners, Ltd. *1999. Forward Study of Community Aquaculture: Summary Report.* Prepared for European Commission Fisheries Directorate General. Note: Species mix varies widely between EU countries. Employment estimates are for full-time-employment in production.

(3) Commission of the European Communities. 2002. A Strategy for the Sustainable Development of European Aquaculture. Brussels 19.9.2002, COM(2002) 511 final. Note: Reported production volume is for 2000. Estimated 1998 employment was "at least 80,000 full or part-time workers, equivalent to 57,000 full-time jobs" (page 4).

(4) Stewart, Len (Aquaculture Strategies, Inc.) 2001. Salmon Aquaculture in New Brunswick: Natural Development of Our Marine Heritage. Prepared for New Brunswick Salmon Growers Association Aquaculture Strategies. Note: Estimated person-years emplyment includes 157 in hatcheries, 624 in growout, 537 in processing, 240 in direct services, and 125 in "selling, administration & other." 77.3% of jobs were full-time, 9.6% were part-time, and 13.1% were seasonal."

(5) O'Hara, Frank, Charles Lawton and Matthew York (Planning Decisions, Inc.). 2003. *Economic Impact of Aquaculture in Maine* . Prepared for the Maine Aquaculture Innovation Center. Note: Includes employment at three companies producing 15 million pounds of salmon annually of "over 240 full-time workers" in "freshwater and ocean farming operations, processing plants, and administrative and sales positions."

(6) Highlands and Islands Enterprise and The Scottish Office. 1998. The Economic Impact of Salmon Farming, Final Report. Prepared by Public and Corporate Economic Consultants (PACEC) and Stirling Aquaculture. 124 p. Employment is estimated FTE employment in smolt production and salmon production. The study estimated that additional FTE employment of 4777 is created in "processing, supplier & induced."

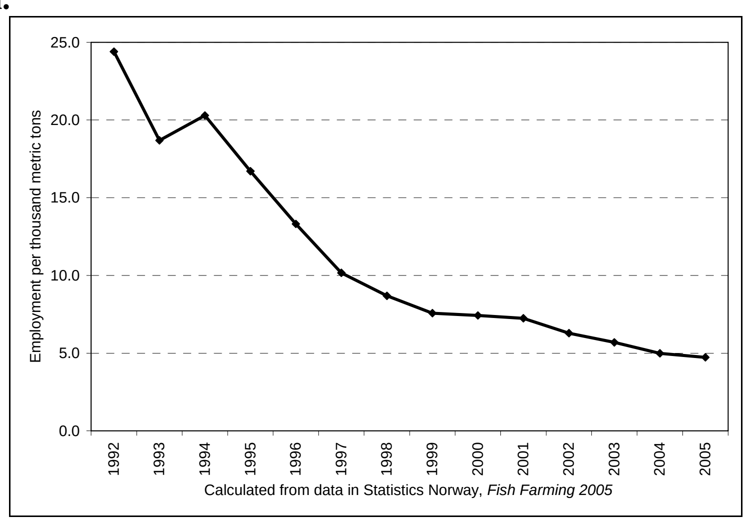
(7) Scottish Executive, 2004. Scottish Economic Report: March 2004. Scottish Salmon Farming. http://www.scotland.gov.uk/library5/finance/ser04-16.asp. Note: Estimates are for FTE employment of 1552 in smolt and salmon farming. Additional FTE employment of 4728 for salmon farming, 1024 for farming suppliers, and 520 for processing suppliers.

(8) Statistics Norway. 2007. Fish Farming 2005. www.ssb.no/nos_fiskeoppdrett. Note: Includes employment in hatcheries.

(9) Hanson, Terrill, Stuart Dean, and Stan Spurlock. *Economic Impact of the Farm-Raised Catfish Industry on the Mississippi State Economy.* Department of Agricultural Economics, Mississippi State University. Note: Includes only employment in catfish production. Additional employment of 3671 was reported in catfish processing. Production of 172,789 metric tons is volume of catfish processed in Mississippi.

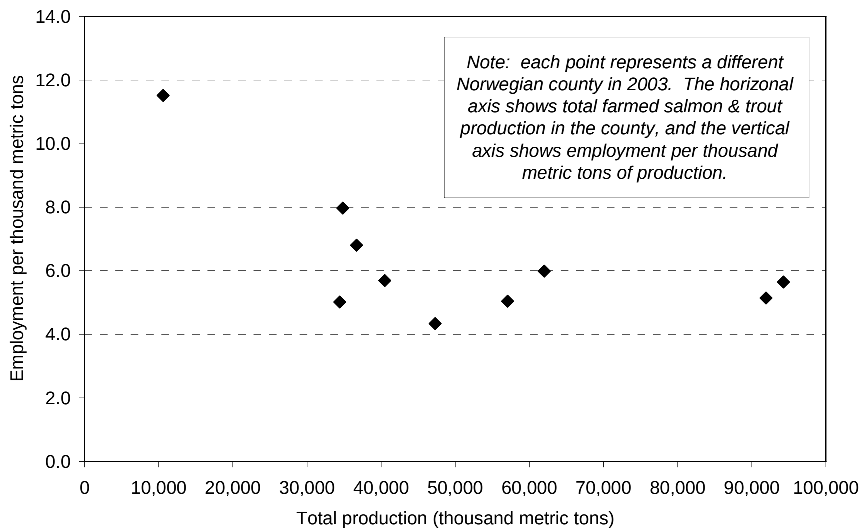
Figure 8.3. Norwegian salmon and trout aquaculture: total production and total employment.

Figure 8.4. Norwegian salmon and trout aquaculture: employment per thousand metric tons of production.



Norwegian aquaculture data also help to illustrate that even farming of the same species in the same country may have different job impacts in different locations—likely reflecting differences in industry scale. As shown in Figure 8.5, there were significant differences between Norwegian counties in the employment per thousand metric tons of production in 2003.

Figure 8.5. Norwegian salmon and trout aquaculture: Employment per thousand metric tons of production, by county.



Calculated from data in Statistics Norway, *Fish Farming 2003*

In general, because of the more difficult working conditions offshore, and the higher cost of transporting workers to offshore facilities, offshore fish farms are likely to be more mechanized and have fewer people working on the farm sites per metric ton of production than inshore farms growing the same species. Put differently, where it is possible to replace offshore workers with machines, offshore farm operators are likely to try to do so. This effect will be amplified to the extent that offshore farms are larger scale than inshore farms.[3]

However, some parts of offshore fish farming operations may employ more labor than inshore operations producing comparable species and volumes. For example, because of longer distances from shore facilities to farms, offshore farms may create relatively more jobs in transporting fish, feed, equipment and people to and from farms.[4]

Potential Total Employment Created by U.S. Offshore Aquaculture

Clearly the employment created by U.S. offshore aquaculture would depend upon the volume of offshore aquaculture production, the mix of species which are farmed, and the scale and technology of individual farming operations. However, given observed levels of employment in existing aquaculture, is possible to make reasonable estimates about the potential scale of total U.S. employment which might be created by U.S. offshore aquaculture.

[3] As discussed in other chapters, not all offshore farming operations would necessarily be large-scale or capital intensive.

[4] Note, however, that locating a farm farther offshore does not necessarily imply a greater transportation distance from shore facilities. Depending on terrain and infrastructure development, the distance from a shore facility straight out to an offshore farm may be shorter than the distance along the coast to a suitable inshore farming site.

Table 8.5. Potential employment created by U.S. offshore aquaculture implied by different combinations of assumptions.

	Assumed direct farming employment per thousand metric tons	Assumed Annual Offshore Production (metric tons)		
		50,000	100,000	500,000
Direct farming employment only	5	250	500	2,500
	20	1,000	2,000	10,000
	50	2,500	5,000	25,000
Assuming 2 total jobs per direct farming job	5	500	**1,000**	**5,000**
	20	**2,000**	**4,000**	**20,000**
	50	**5,000**	10,000	50,000
Assuming 5 total jobs per direct farming job	5	1,250	**2,500**	**12,500**
	20	**5,000**	**10,000**	**50,000**
	50	**12,500**	25,000	125,000
Assuming 10 total jobs per direct farming job	5	2,500	5,000	25,000
	20	**10,000**	20,000	100,000
	50	**25,000**	50,000	250,000

Note: Relatively more likely combinations of assumptions are shown in **bold**.

Table 8.5 shows the potential total employment implied by different combinations of three assumptions:

- Total annual production. The table shows implications of annual production from 50,000 to 500,000 metric tons.

- Direct farming employment per thousand metric tons. The table shows implications of direct employment ranging from 5 jobs per thousand metric tons (large-scale highly efficient Norwegian salmon and trout farming) to 50 jobs per thousand metric tons (averages across all aquaculture in some regions).

- Ratio of total employment to direct farming employment. The table shows implications of between 2 and 10 total jobs per direct farming jobs. Note that the lower assumption would exclude "downstream" employment created in transportation, wholesaling, retail and food service, on the assumption that in the absence of U.S. offshore aquaculture these jobs would be created by fish imports.

As can be seen in the table, these different assumptions imply a very wide range of potential total employment. However, we may make some reasonable inferences about the relative likelihood of different combinations of assumptions. First, employment would grow over time as the scale of total production increases. Thus the estimates in the left-hand column are more likely to represent employment created over the first ten years, while estimates in the right hand column become more likely over a longer period.

Second, as the total volume of offshore aquaculture production increases it is likely that labor efficiency would increase, resulting in fewer (perhaps 5-20) direct farming jobs per thousand metric tons of production.

Third, as the total volume of offshore aquaculture production increases it is increasingly likely that U.S. offshore production would be displacing imports rather than increasing U.S. consumption. Thus the total net increase in jobs created per direct farming jobs might tend to decline as the scale of production increases.

Given this reasoning, the figures shown in bold in the table represent relatively more likely combinations of assumptions. In general, it seems reasonable to conclude that if the United States produced 500,000 metric tons of fish annually in offshore aquaculture, this would increase total U.S. employment by between 5,000 and 50,000 jobs.

Comparing Employment in Wild Fisheries and Aquaculture

Table 8.6 provides similar estimates of average annual employment per thousand metric tons in several wild fisheries. As in aquaculture, there is wide variation between species in how much employment is created in harvesting a given volume of fish. For any given species, employment created in by fish harvesting also varies from year to year, reflecting differences in total harvest volumes. In general, the ranges of average annual employment per thousand metric tons in these wild fisheries are comparable to those for aquaculture shown in Table 8.4.

An important difference between aquaculture and wild fisheries is that employment in wild fisheries is more seasonal. For example, peak monthly employment in Alaska salmon fisheries, which occur primarily in the summer, is more than four times as high as average annual employment. This means that wild fisheries tend to provide jobs for relatively more workers, working relatively less of the year, to produce a given volume of fish.

In comparing wild fisheries and aquaculture, such as comparing the employment estimates in Tables 8.6 and 8.4, it is important to keep in mind that the policy choice faced by the United States is not between harvesting fish in wild fisheries or growing fish in farms. With most United States wild fisheries fully exploited, is not an option for the United States to produce significantly more fish in wild fisheries. Rather, the policy choice is how much fish the United States will grow in fish farms. Even if commercial fishing tended to employ far more workers than aquaculture—which available data suggest is not the case—we would not have the option of creating more jobs by increasing commercial fish harvests. In contrast, aquaculture does provide an opportunity to create more jobs in fish production.

What Kinds of Jobs Will Offshore Aquaculture Create?

On average, the jobs created in offshore aquaculture are likely to be higher-skilled and higher-paying than the jobs in onshore and inshore aquaculture for similar species. These jobs will include, for example, operation and maintenance of vessels and remote monitoring and feeding facilities and fish nutrition and fish health specialists.

Table 8.6. Estimated average annual employment per thousand metric tons of harvest, selected wild fisheries.

Area	Species	Year	Harvest (thousands of metric tons)	Estimated average annual employment	Estimated employment per thousand metric tons	Ratio, maximum to average annual employment
Alaska	Salmon	2000	322	4,295	13	4.5
		2001	349	3,761	11	4.5
		2002	282	3,073	11	4.4
		2003	333	3,424	10	4.4
		2004	363	3,526	10	4.4
		2005	434	3,817	9	4.3
Alaska	Halibut	2000	33	1,413	43	1.9
		2001	34	1,383	41	1.8
		2002	35	1,356	38	2.0
		2003	35	1,327	38	1.9
		2004	35	1,279	37	1.9
		2005	34	1,132	34	2.1
Alaska	Sablefish	2000	16	453	28	2.3
		2001	14	466	33	2.0
		2002	15	437	30	2.1
		2003	16	463	29	1.8
		2004	18	450	25	2.0
		2005	17	449	27	2.0
British Columbia	All species	2000	146	4600	32	N/A
		2001	192	5400	28	N/A

Sources: Alaska employment data : Alaska Department of Labor and Workforce Development, Research and Analysis Division (almis.labor.state.ak.us). Alaska salmon harvests: Alaska Commercial Fisheries Entry Commission (www.cfec.state.ak.us). Alaska sablefish and halibut harvests: National Marine Fisheries Service, Annual Commercial Landings Statistics (http://www.st.nmfs.gov/st1/commercial/landings/annual_landings.html). British Columbia harvests: Ministry of Agriculture and Lands (http://www.al.gov.bc.ca/fish_stats/statistics.htm); British Columbia employment: British Columbia Ministry of Management Services, British Columbia's Fisheries & Aquaculture Sector, September 2002.

As with other higher-skilled and higher paying jobs, not all of the new jobs created by U.S. offshore aquaculture will necessarily be taken by current residents of those communities nearest offshore aquaculture facilities. The industry is likely to seek the most qualified employees it can find from a broader regional or national pool of workers with the requisite skills. However, local communities may be able to influence local hiring through training programs or tax incentives. Local training or hiring requirements could potentially be incorporated in enabling regulations for offshore aquaculture.

Commercial fishermen would be well-skilled for and could potentially work in many of the jobs that might be created by offshore aquaculture, particularly those that involve vessel operations, maintenance of offshore operations, and transportation of fish. However, some (but not all) kinds of offshore aquaculture—particularly large-scale corporate farms--may involve a very different working environment than the small-scale, family owned business that characterize much (but not all) of the United States commercial fishing industry. Jobs in offshore aquaculture are likely to have similar advantages (stable year-round employment, health-care benefits, opportunities for training and advancement) and disadvantages (non-local ownership and management, company bureaucracy) typically associated with larger companies operating in remote areas. Some but not all fishermen and other coastal community residents would welcome these job opportunities.

In considering the types of jobs created by offshore aquaculture, it is important to keep in mind the point--emphasized earlier in this chapter--that most of these jobs will not be working on offshore farms or working for offshore aquaculture companies. Rather, most of the jobs will be in a wide variety of upstream and downstream activities ranging from hatcheries, feed manufacturing, fish processing and distribution (more obvious examples) to soybean farming.

Market-Driven Impacts of Offshore Aquaculture

We next review potential “market-driven impacts” of U.S. offshore aquaculture on prices and production volumes of U.S. wild and farmed fish, how these might affect net economic benefits of fishing and aquaculture to U.S. fishermen, fish farmers and consumers.

Clearly, aquaculture can have dramatic impacts on markets for wild fisheries. As we discuss in more detail below, prices paid to United States wild salmon fishermen and processors fell dramatically as world farmed salmon production expanded during the 1990s--causing significant economic difficulties for Alaska salmon fishermen, processors and fishing communities (Knapp et al, 2007). U.S. shrimp fishermen have experienced similar effects of competition from farmed fish.

Given this experience, it is not surprising that many commercial fishermen oppose fish farming. But the public policy considerations relevant to market-driven impacts of U.S. offshore aquaculture go beyond how competition from farmed fish affects prices of wild fish. They also include the benefits to consumers of lower fish prices, the long-term impacts of aquaculture on demand for fish (including wild fish), and the benefits to wild fisheries and consumers deriving from changes in wild fisheries driven by competition. Perhaps most importantly, they include the fact that aquaculture production will continue to expand globally—and most market driven impacts of aquaculture will occur—regardless of whether the United States rejects or embraces offshore aquaculture.

Theoretical Framework for Analysis of Market-Driven Impacts

Basic supply and demand analysis provides a useful theoretical framework for thinking about how aquaculture may affect prices and net benefits to fishermen, fish farmers, and consumers. Below we first discuss potential short-run effects resulting from the effects of aquaculture on fish supply. We then discuss potential longer-run effects resulting from the effects of aquaculture on fish demand. Finally, we discuss the relative extent to which these effects are experienced by U.S. or foreign groups, and the extent to which U.S. aquaculture policy is able to influence the effects of aquaculture on prices and benefits to different groups. Our discussion applies to the effects of all aquaculture, not just to offshore aquaculture.

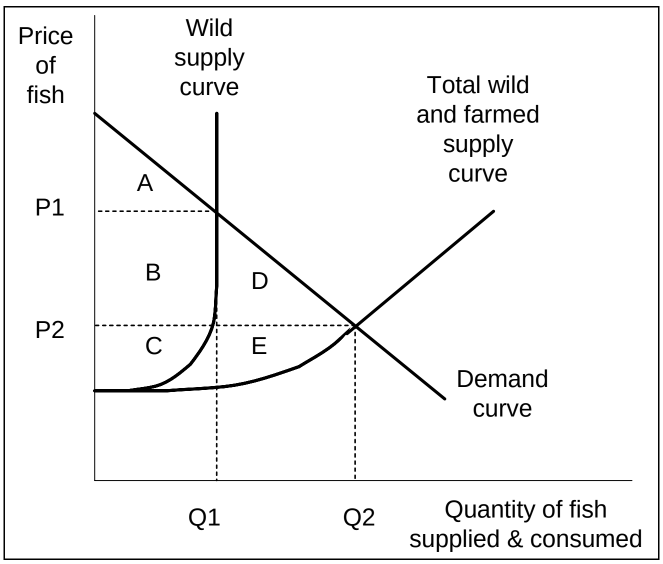
Short-Run Market-Driven Impacts of Aquaculture

Suppose that prior to the development of aquaculture all fish supply is from a wild fishery. The supply curve for fish shows the total volume of fish offered for sale at any given price (Figure 8.6). The supply curve is initially upward sloping, and becomes vertical at the maximum annual quantity available from the wild fishery (which we assume is limited by regulation).[5]

The intersection of the wild supply curve with the demand curve determines the equilibrium price P1 and the equilibrium quantity sold Q2. At this price, the area of the graph labeled A shows "consumer surplus," or the difference between what consumers would have been willing to pay for fish (as shown by the demand curve) minus the price P1 that they actually pay. Together, areas B and C show "producer surplus," or the difference between the price received by wild fish producers and the price for which they would have been willing to supply the fish.

Consumer surplus is a measure of net benefits to consumers from the fishery. Producer surplus is a measure of net benefits to fishermen from the fishery. Total benefits to society from the fishery are represented by areas A + B + C.

Figure 8.6. Supply and demand curves for fish.



Now suppose that aquaculture provides a new source of fish supply.[6] The effect of the development of aquaculture is to shift the supply curve to the right, to the new "total wild and farmed supply curve." This new total supply curve is the horizontal sum of the wild supply curve and an upward sloping farmed supply curve (which is not shown in the graph).

[5] To simplify the discussion we assume that prices do not affect fish supply by affecting fish stocks, which can result in a backward-bending supply curve such as that depicted for an equilibrium common-property fishery in Chapter 8.
[6] To simplify the discussion we assume initially that wild fish and farmed fish are identical products and sell for the same price.

As supply shifts from the old "wild supply curve" to the new "total wild and farmed supply curve,", the equilibrium price falls from P1 to P2, and the equilibrium quantity supplied and consumed increases from Q1 to Q2. At the new lower price there is a slight decline in the volume of wild fish supplied.

At the new equilibrium, consumer surplus is now represented by the sum of areas A, B and D, while producer surplus is now represented by the sum of areas C and E.

How are different groups been affected by the introduction of aquaculture in the short run?

- Fishermen are harmed. Their producer surplus declines from areas B + C to only area C, or by an amount represented by area B.
- Fish farmers benefit. They earn producer surplus represented by area E.
- Consumers benefit. Their consumer surplus increases from area A to areas A + B + C.

Total benefits to society increase from areas A + B + C to areas A + B + C + D + E. Areas D + E represent an increase in net benefits to society from aquaculture, which are respectively the consumer surplus and producer surplus from aquaculture. However, there is a redistribution of the benefits of the wild fishery from fishermen to consumers by an amount represented by area B. <u>Put simply, in the short run, if aquaculture depresses the price of wild fish, fishermen lose and consumers gain by an equivalent total amount</u>. Note that the relative scale of these effects on fishermen, consumers and fish farmers depend upon the assumptions we make about the shape of the supply and demand curves.

Because there are far fewer fishermen than consumers, the effects upon individual fishermen are far greater than the effects on individual consumers. As the price falls, an individual fisherman may see a very large drop in his income. An individual consumer will experience a correspondingly large drop in the price of the fish she buys--but this will not be anywhere as significant for her overall welfare as the loss of income is for the fisherman.

<u>Long-Run Market-Driven Impacts of Aquaculture</u>

The preceding analysis assumes that the demand for fish is unchanged by the introduction of aquaculture. However, over time introducing new supply from aquaculture is likely to increase demand for fish, shifting the demand curve out.

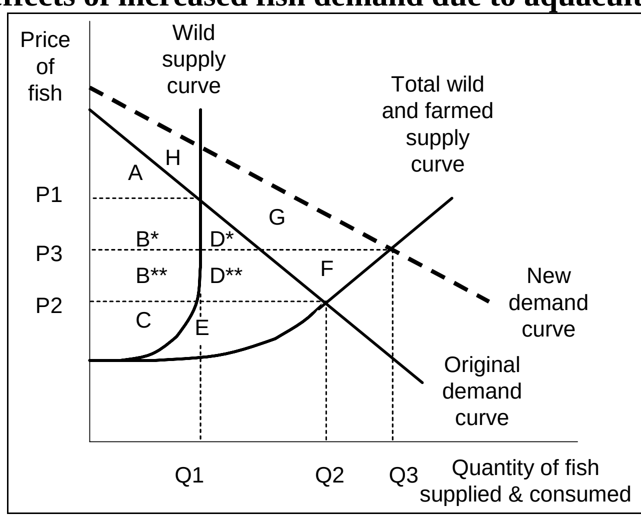
There are several reasons for which new supply from aquaculture is likely to increase fish demand over time. First, at any given time, demand for fish reflects consumers' tastes and preferences, which in turn reflect their past consumption experiences. If a particular fish species is expensive, consumers who have not eaten it in the past are less likely to buy it in a store or order it in a restaurant. However, if the price falls and consumption increases (as depicted by the increase in consumption from Q1 to Q2 in Figure 8.6), new consumers may try the fish. If they enjoy eating it and develop a taste for it, over time they may be willing to pay a higher price for it than they would have previously.

Second, consumer demand for fish is limited by its availability in stores and restaurants. Even if consumers like a fish and are willing to pay a high price for it, they won't buy it if it is not in their local stores or on their local menus. As aquaculture supply expands, fish are offered for sale in more geographic locations, at more kinds of stores and restaurants, and at more times of the year—thus increasing the total demand at any given price.

Third, fish farmers engage in marketing in a systematic effort to increase demand. They recognize that their economic success depends critically on growing the market for their products. Marketing by fish farmers is not just advertising to consumers. Rather, it is a systematic approach to understanding and responding to the needs of both consumers and store and restaurant buyers, reflected in (for example) product forms, quality standards, packaging, and timing and volume of fish deliveries, long-term contracts, supply guarantees, payment terms, etc. Without competition from aquaculture, fishermen have far less incentive to engage in marketing, particularly when prices are high, because they are limited by nature in the volume of fish that they can supply.

Figure 8.7 illustrates potential effects of an increase in fish demand due to aquaculture. The equilibrium price increases from P2 to P3, and the quantity of fish supplied and consumed increases from Q2 to Q3.

Figure 8.7. Potential effects of increased fish demand due to aquaculture.



How does an increase in fish demand affect how different groups are affected by the introduction of aquaculture?

- Fishermen are not harmed as much. Their producer surplus declines by an amount represented by area B*, rather than by the combined areas B* + B**.

- Fish farmers benefit more. Their producer surplus increases by an amount represented by the combined areas E + D** + F, rather than by only area B.
- Some consumers lose but others benefit. As the price rises from P2 to P3, those consumers whose demand was represented by the original demand curve experience a

loss of consumer surplus represented by areas B** + D**. However, new consumers (as well as former consumers who enjoy fish more) experience an increase in consumer surplus represented by areas H + G.

Higher demand increases total benefits to society by an amount represented by areas H +G + F, which includes both new consumer surplus (areas H + G) as well as new producer surplus for fish farmers (area F). Higher demand also reduces the extent to which aquaculture results in a shift of net benefits from fishermen to consumers. Note that if aquaculture results in a sufficiently great increase in demand, there may be no long-term effect on the price and fishermen may not be harmed at all.

Another potential change in demand over time may be a differentiation in consumer demand between wild and farmed fish. Some consumers may perceive wild fish as superior to farmed fish, and be willing to pay a higher "premium" price for wild fish than for farmed fish. To the extent that such a wild demand "premium" emerges, it would further mitigate the long-term effects of aquaculture on wild fishermen.

Market-Driven Impacts of Aquaculture on Americans

The preceding analysis has considered the effects of aquaculture on fishermen, fish farmers and consumers without regard to the question of whether these groups are American or foreign. Suppose however that fish are traded freely, and we are interested in how aquaculture may specifically affect American fishermen, fish farmers, and fish consumers, and overall net benefits to Americans.

Consider first, for purposes of illustration, the eight "either/or" scenarios, shown in Table 8.7, in which fishermen, fish farmers, and consumers are either all Americans or all foreigners. Fishermen stand to "lose" from aquaculture (due to lower prices) while fish farmers and consumers stand to gain.[7]

The economic effects of fish farming *on Americans* clearly depend on whether fishermen, fish farmers, and consumers are Americans:

- Scenarios 1-3: If no American fishermen are catching a particular fish species , then aquaculture clearly benefits Americans, by providing economic opportunity for American fish farmers, reducing prices and expanding supply for American consumers, or both.

- Scenario 4: If fishermen, fish farmers and consumers are all Americans, aquaculture increases net benefits to Americans by providing economic opportunities to American fish farmers. As discussed above for Figure 8.4, American fishermen lose and American consumers gain by an equivalent amount from the decline in prices.

[7] For purposes of illustration, in this section we ignore the possibility that aquaculture may expand fish demand, thus partially or even fully offsetting negative effects of aquaculture on prices and on fishermen.

Table 8.7. Potential implications of aquaculture for Americans.

Scenario	Who Producers & Consumers are			How Americans are affected*			Change in net benefits to Americans	Area of Figure X representing change in net benefits to Americans
	Fishermen	Farmers	Consumers	Fishermen	Farmers	Consumers		
1	Foreign	US	US	No effect	Gain	Gain	Increase	B+D+E
2	Foreign	US	Foreign	No effect	Gain	No effect	Increase	E
3	Foreign	Foreign	US	No effect	No effect	Gain	Increase	B+D
4	US	US	US	Lose	Gain	Gain	Increase	D+E
5	US	Foreign	US	Lose	No effect	Gain	No net change	
6	US	Foreign	Foreign	Lose	No effect	No effect	Decrease	-B
7	US	US	Foreign	Lose	Gain	No effect	Uncertain	E-B
8	Foreign	Foreign	Foreign	No effect	No effect	No effect	No effect	

*Table assumes that aquaculture harms fishermen by lowering prices, benefits consumers by reducing prices and expanding supply, and benefits farrmers. Note that if aquaculture expands demand sufficiently, prices will not necessarily fall.

- Scenario 5: If foreign fish farmers reduce prices paid by American consumers to U.S. fishermen, there is no change in net benefits to Americans. Again, American fishermen lose and American consumers gain by an equivalent amount from the decline in prices.

- Scenario 6: The worst situation for Americans occurs if the fishermen (who stand to lose) are Americans while the fish farmers and consumers (who stand to gain) are foreigners.

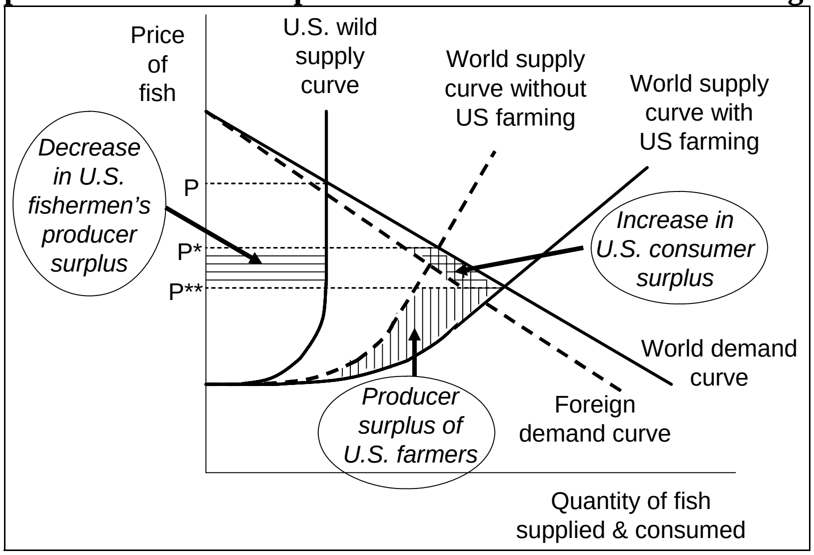
- Scenario 7: If both American fishermen and American fish farmers export fish to a foreign market, then the effect on net benefits to Americans is uncertain: it depends on the relative magnitudes of fishermen's loss from lower prices and farmers' gain from increased economic opportunity.

Table 8.7 depicts "either/or" situations in which fishermen, fish farmers and consumers are either all American or all foreign. However, the situation most relevant to discussion of U.S. offshore aquaculture is one in which consumers may include both foreigners and Americans, and fish farmers may include both foreigners and Americans. The relevant policy issue for discussion of U.S. offshore aquaculture is how U.S. production may affect Americans, given that foreign aquaculture production is likely to grow—with major effects on world seafood markets—regardless of the extent of U.S. production.

Figure 8.8 depicts a situation in which the United States is the only producer of wild fish, but fish are consumed by both foreigners and Americans, and farmed fish may be produced by both foreigners and Americans. Even if there is no U.S. fish farming, the effect of foreign fish farming on Americans is to depress the price paid to U.S. fishermen from P to P* and to reduce prices and increase consumption by American consumers. The effect of U.S. fish farming would be to shift the world supply curve further to the right, depressing the price further from P* to P**.

The effects on Americans include a further decrease in U.S. fishermen's producer surplus, a further increase in U.S. consumer surplus, and producer surplus for U.S. fish farmers.

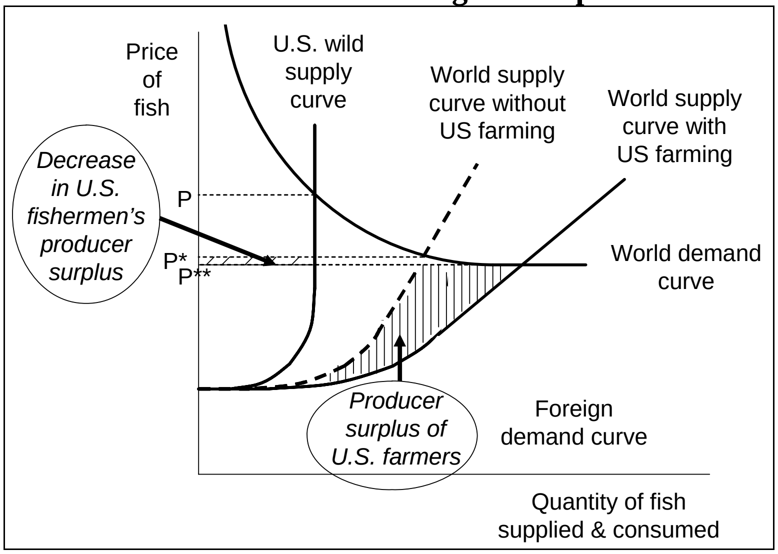
Figure 8.8. Comparison based on the presence/absence of U.S. fish farming.



The relative scale of these effects depends on the shapes of the U.S. and foreign demand and supply curves, and in particular on the price sensitivity ("elasticity") of world demand and supply. Suppose, as depicted in Figure 8.9, that as prices decline and consumption increases world demand becomes relatively more price-sensitive (elastic). At high prices and low consumption the demand curve is relatively more vertical; at low prices and high consumption the demand curve becomes relatively more horizontal.

If there is no U.S. fish farming, foreign fish farming still results in a large increase in supply over wild production, which significantly depresses the price received by U.S. fishermen from P to P*. However, if American fish farmers now increase world supply further, there will be only a limited further effect on prices. Thus, in this situation, American fish farming would have relatively little effect on U.S. fishermen, while providing significant benefits for U.S. farmers.

Figure 8.9. The potential effect of U.S. fish farming on fish prices.



Summary: Theoretical Market-Driven Impacts of Aquaculture

We may summarize the foregoing theoretical discussion of market-driven effects of aquaculture as follows:

- In the short run, aquaculture tends to lower fish prices by increasing the supply of fish, harming fishermen but benefiting consumers.

- Over the longer run, aquaculture tends to increase the demand for fish as consumers become more familiar with fish; as fish become available in more locations, at more times, and in more product forms; and as fish farmers engage in systematic marketing to expand demand. Increasing demand tends to offset the effects of higher supply, resulting in less of a decline in fish prices.

- How American fishermen and consumers would be affected by U.S. offshore farming of a particular species depends upon their relative shares of world supply and demand for that species (and closely competing species), and the price-sensitivity ("elasticity") of world fish demand and supply for that species (and closely competing species). Net benefits to Americans from U.S. aquaculture will tend to be higher, the greater the extent to which consumers are Americans and completing wild and farmed producers are foreigners.

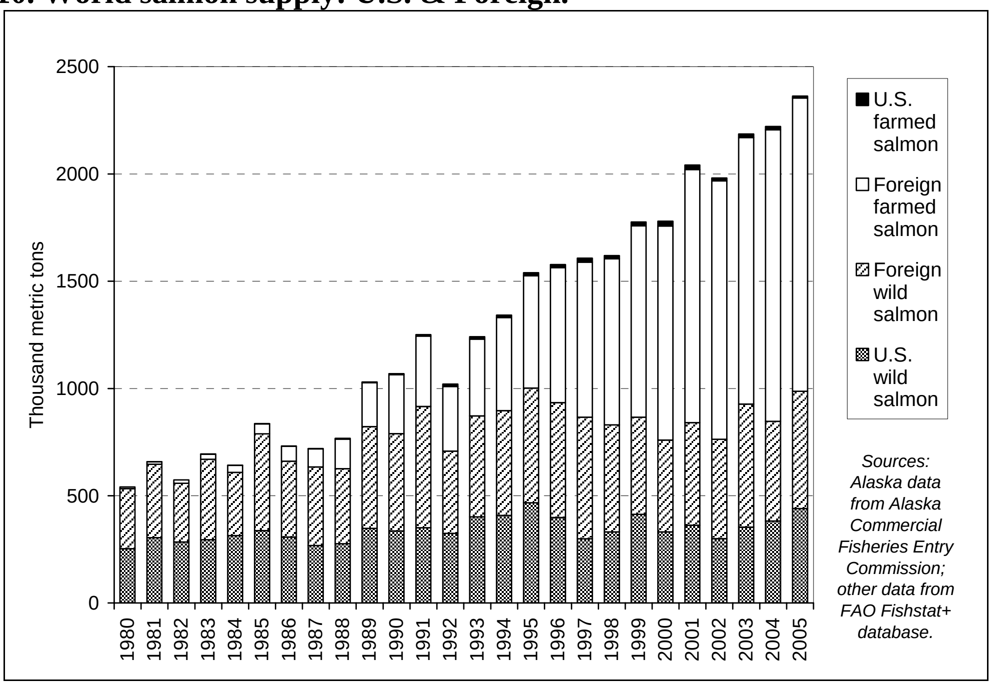
- Even if foreign fish farming significantly depresses prices for U.S. fishermen, that does not necessarily mean that U.S. fish farming would result in further significant effects on fish prices and U.S. fishermen. If demand becomes more price-responsive ("elastic" at lower prices and higher consumption volumes, the effect of U.S. farmed production on U.S. fishermen may be relatively small.

Market-Driven Impacts of Salmon Aquaculture

In considering potential market-driven impacts of U.S. offshore aquaculture, it is useful to consider what the market-driven impacts of salmon aquaculture have been for the United States. As shown in Figure 8.10, in the early 1980s, world salmon production was almost entirely from wild fisheries. Between 1980 and 1985, United States wild salmon accounted for 46% of total world salmon supply. Over the next twenty-five years, world farmed salmon production[8] grew very rapidly, resulting in a dramatic increase in total world supply and a decline in the share of U.S. wild salmon in world supply to 17% for the years 2000-2005.

Almost all of the farmed salmon production occurred outside the United States, which has never accounted for more than 3% of farmed salmon production since the 1980s (and only 1% since 2002). The fact that the United States is not a significant producer of farmed salmon is not due to absence of potential farming sites or other technical or economic constraints. Rather, it primarily reflects policy choices, including a ban on finfish farming in Alaska and regulatory constraints in other states. Our purpose in the subsequent discussion is not to argue for or against these policy choices, but rather to examine the market-driven impacts of salmon aquaculture on U.S. fishermen and consumers.[9]

Figure 8.10. World salmon supply: U.S. & Foreign.



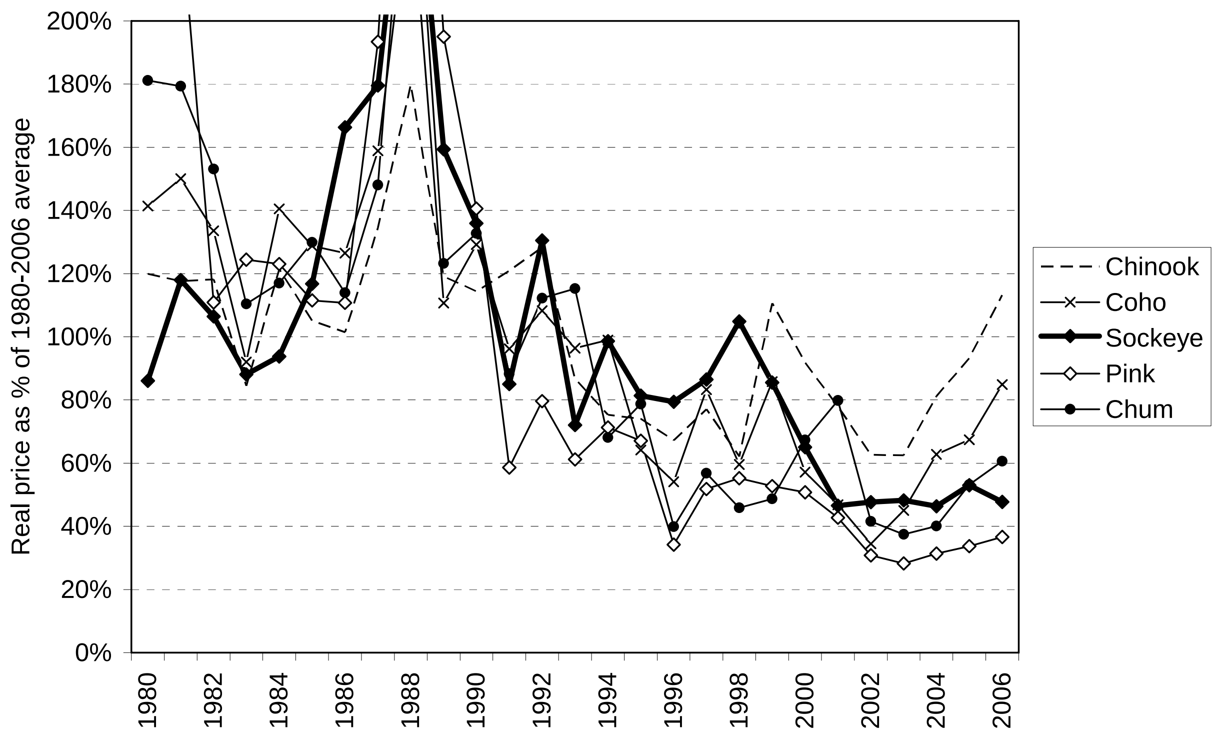
After peaking in the late 1980s, "ex-vessel" prices paid to Alaska fishermen for all five species of salmon fell dramatically over a 14-year period ending in 2002 (Figure 8.11). The most important cause of the decline in prices was competition from farmed salmon in the

[8]With farmed salmon we include trout farmed in marine pens, a product very similar to farmed salmon which competes directly with farmed and wild salmon.

[9] The following discussion is based on analysis in Knapp et al, *The Great Salmon Run: Competition Between Wild and Farmed Salmon* (2007).

Japanese, American and European markets for frozen and fresh salmon. Note however that farmed salmon was not the only cause of the decline in prices. Numerous other factors, including large wild salmon harvests, a recession in Japan, and declining consumer demand for canned salmon, also played a role. .

Figure 8.11. Indexes of real Alaska salmon ex-vessel prices, 1980-2006.



Source: Alaska Department of Fish & Game. 1988 price indexes peaked well above 200% for most species.

The decline in wild salmon prices, combined with a drop in returns of sockeye salmon (the most valuable species) caused an economic crisis in the wild salmon industry and great hardship for thousands of salmon fishermen and fishing communities. Fishermen's revenues declined dramatically while their costs continued to rise. Values of salmon fishing permits and boats declined dramatically, and many fishermen quit fishing. Many Alaska salmon processing plants closed.

It is difficult to estimate precisely how much income U.S. salmon fishermen may have lost because of salmon aquaculture, partly because other factors have also affected salmon prices, and partly because lower harvests also contributed to the decline in income. Nevertheless, it is clear that U.S. salmon fishermen were significantly harmed by salmon aquaculture, as predicted by the above theoretical discussion.

But it is also clear that the cause of the decline in U.S. salmon fishermen's income was not U.S. salmon farming, but rather salmon farming in foreign countries. The effects of salmon farming on U.S. fishermen's prices occurred despite the fact that U.S. farmed salmon production was only a tiny share of world production. Policy choices which restricted U.S. farmed salmon production did not protect U.S. fishermen from the market-drive effects of farmed salmon.

Nor is it likely that *any* U.S. policies could have protected U.S. salmon fishermen from the market-drive effects of salmon aquaculture. The most important fresh and frozen markets for Alaska salmon were in foreign countries—particularly Japan—rather than the United States (Table 8.8). Even if the United States had banned imports of farmed salmon, it would not have prevented the competition which Alaska sockeye salmon encountered in the Japanese salmon market from farmed Chilean and Norwegian salmon and trout. In a globalized seafood industry in which U.S. fishermen are heavily dependent upon export markets, it is impossible for U.S. fishermen to escape competition from farmed fish—regardless of U.S. policy towards aquaculture.

Table 8.8. Estimated end-market shares for U.S. wild salmon production, 2000-2004.

		Species					
		Sockeye	Pink	Chum	Coho	Chinook	TOTAL
Average annual harvest value ($ millions)		$123	$40	$36	$18	$14	$232
% of average annual harvest value		53%	17%	16%	8%	6%	100%
Estimated end-market shares	US fresh & frozen markets	12%	4%	41%	41%	87%	17%
	Export fresh & frozen markets	53%	26%	52%	50%	13%	42%
	Canned markets	35%	70%	7%	9%	1%	40%
	Total	100%	100%	100%	100%	100%	100%
Farmers competing with U.S. fishermen		Mostly foreign	Mostly foreign	Mostly foreign	Mostly foreign	Mostly foreign	Mostly foreign
Consumers of U.S. fresh and frozen salmon competing with farmed salmon		Mostly foreign	Mostly foreign	US & foreign	US & foreign	Mostly US	US & foreign

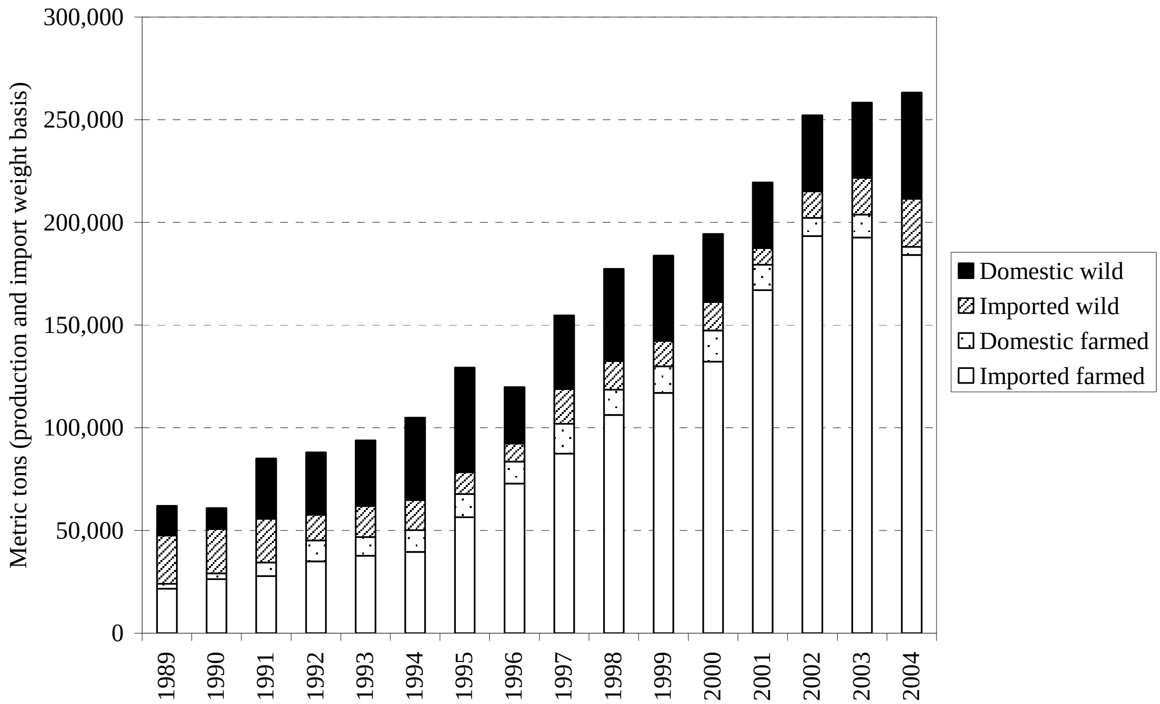
Source: Knapp et al (2007).

The dramatic growth in world salmon supply during the 1990s was reflected in a corresponding growth in U.S. consumption of salmon (Figure 8.12). Almost all of this growth in consumption was farmed salmon, almost all of which was imported, primarily from Canada and Chile.

In the years prior to 2002, the increase in U.S. salmon consumption was accompanied and encouraged by a decline in U.S. prices for both farmed and wild salmon, as shown in Figures 8.13 and 8.14 for wholesale prices of farmed Atlantic salmon, wild chum salmon and wild chinook salmon. (Data showing long-term trends in retail prices are not available, partly because of the wide variation in retail products and retail stores).

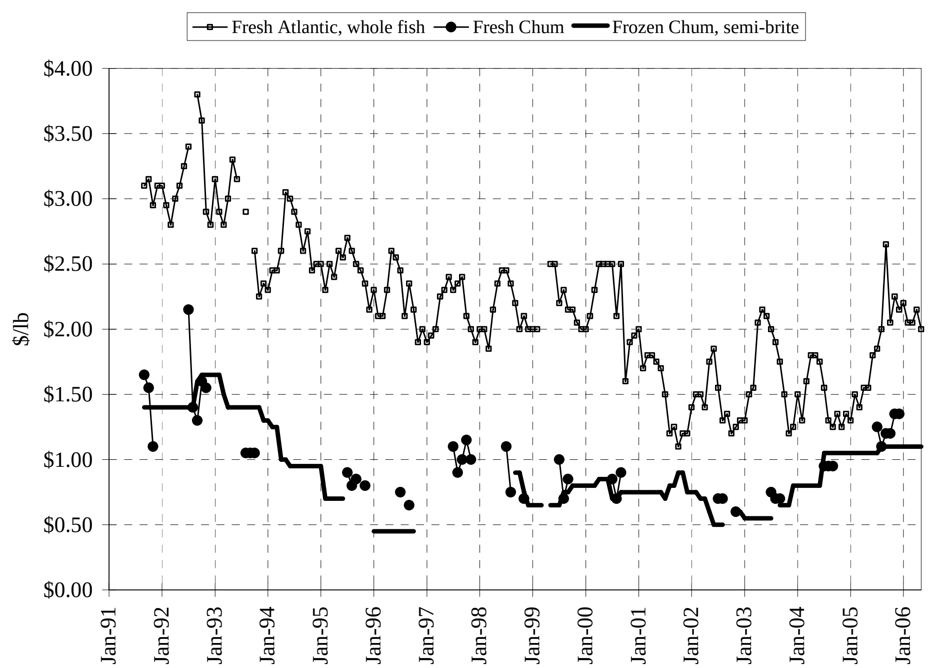
United States consumers benefited from lower prices and from the availability of much larger volumes of salmon in the U.S. market. The rapid growth in consumption demonstrates that farmed salmon—which made salmon available to U.S. consumers in more places, over more of the year, and in convenient new product forms--was embraced by U.S. consumers.

Figure 8.12. Estimated U.S. fresh and frozen salmon consumption: wild & farmed.



Source: Knapp et al, *The Great Salmon Run: Competition Between Wild and Farmed Salmon* (2007).

Figure 8.13. U.S. wholesale prices for farmed Atlantic salmon and wild chum salmon.



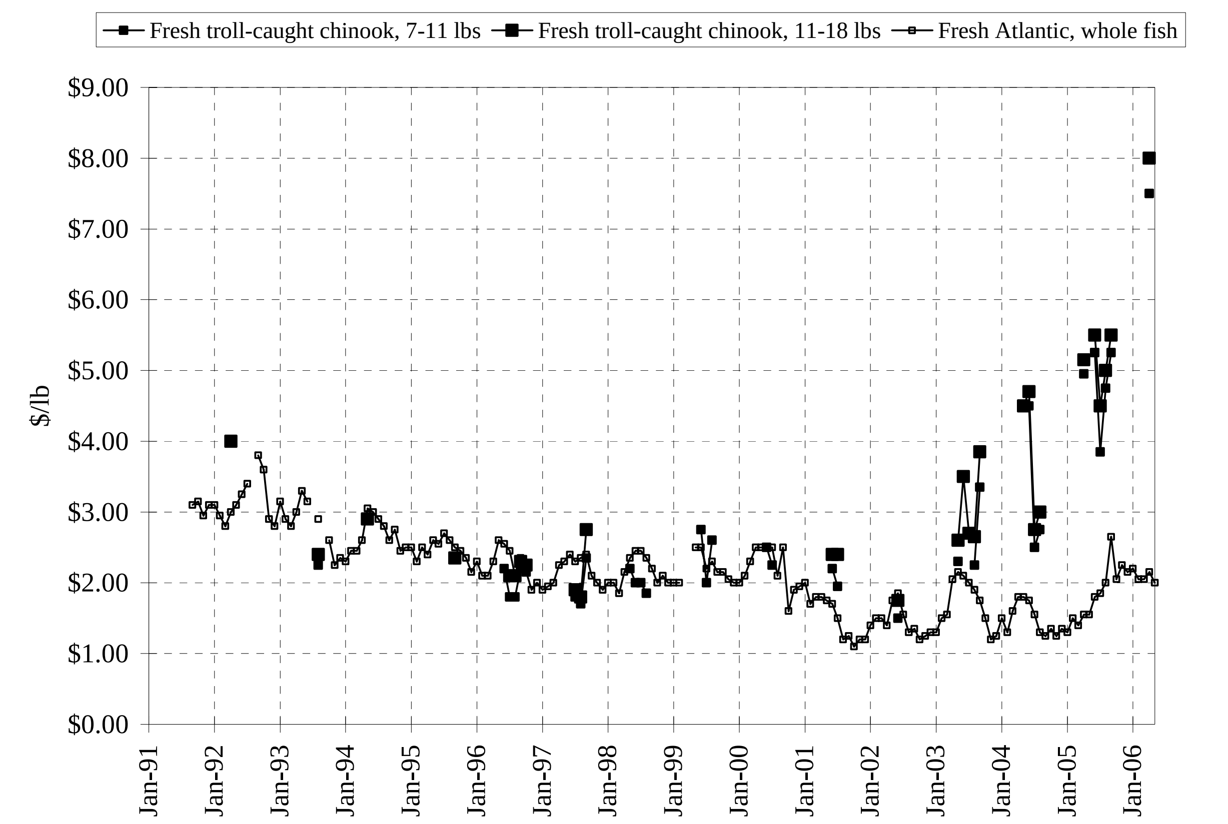
Source: Urner Barry Publications, Inc., Seafood Price Current. Prices are low list prices for Chilean 2-3 lb fillets, FOB Miami; 6-8 lb Atlantics, FOB Northeast; 4-6 lb gillnet head-off fresh chum, FOB Seattle; 6-9 lb H&G frozen chum, FOB Seattle.

Falling wild salmon prices prior to 2002 illustrate the predicted "short run" negative effects of fish farming for fishermen discussed above. Note, however, that after 2002 U.S. wholesale prices for both farmed and wild salmon were *rising* (Figures 8.13 and 8.14). Similarly, "ex-vessel" prices paid to Alaska salmon fishermen were rising (Figure 8.11). Wholesale salmon prices also increased in the European Union, the world's largest salmon market.

The fact that salmon prices rose after 2002 despite continued growth in world salmon supply during this period is a clear indicator that world demand for salmon was rising, consistent with the predicted "long run" effects of fish farming on demand discussed above.

Figure 8.14 also clearly demonstrates a growing price premium over farmed salmon for wild troll-caught chinook salmon, reflecting growing consumer differentiation between wild and farmed salmon. For this particularly high-quality species and product (which represents only a small share of total wild salmon supply), prices rebounded to levels of the 1980s. While this has not been the case for other salmon species, the increase in prices experienced since 2002 shows that the long-run effects of salmon aquaculture on wild salmon prices may not be as significant as the initial effects.

Figure 8.14. U.S. Wholesale prices for farmed Atlantic salmon and wild chinook salmon.



Source: Urner Barry Publications, Inc., Seafood Price Current. Prices are low list prices for Chilean 2-3 lb fillets, FOB Miami; 6-8 lb Atlantics, FOB Northeast; and 7-11 lb and 11-18 lb troll-caught head-on chinook salmon.

The strengthening of wild salmon prices since 2002 also reflects an improvement in both quality and marketing, as the wild salmon industry worked to compete more effectively with farmed salmon. This suggests that another effect of fish farming may be changes within wild fisheries to better address the demands of consumers. In effect, aquaculture brings competition to wild fisheries which had previously, like a monopoly, faced no competition. Just as competition for a monopoly tends to benefit consumers not only by lowering prices but also making the monopoly industry more responsive to consumers' demands, competition for wild fisheries may bring about changes which, although painful for fishermen, benefit not only consumers but ultimately the wild fishery as well.

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